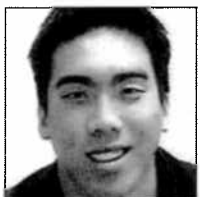


# The Cockroach as a Host for *Trichinella* and *Enterobius vermicularis*: Implications for Public Health

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## Abstract

Cockroaches are known carriers of bacteria and fungi that produce disease in humans. However, the link between pathogenic helminths and cockroaches has not been fully explored. This preliminary study demonstrates *Trichinella* and *Enterobius* (also known as human "pinworm") infestation in cockroaches obtained from a grade school and hospitals in Hawaii. This is the first report of *Trichinella* and *Enterobius* infestation in naturally occurring cockroaches. These results suggest that roaches are an unappreciated hosts for these human pathogens and are potential reservoirs for these nematodes, supporting their persistence and transmissibility in the environment. Given the ubiquitous nature of the cockroach and the human-occupied settings in which the infested roaches were found, public health concerns are apparent. Furthermore, this information may have diagnostic value when examining *Trichinella* and *Enterobius*-infected individuals.

## Introduction

Humans function as hosts in the life cycles of numerous helminths. For *Trichinella*, humans are end-stage hosts.<sup>1,2</sup> Trichinosis typically is spread from one animal to another through the consumption of flesh containing encysted larvae. The domestic pig is the dominant reservoir for *Trichinella spiralis*; however, infection has been observed in rodents.<sup>1,3</sup> The life cycle of *Trichinella* ends when human beings eat infected meat. Here, the cyst walls are digested in the small intestine. After maturation and mating, gravid adult females deposit larvae that enter the intestinal lymphatics. The larvae then spread to peripheral blood and eventually encyst in skeletal muscle. Infection can induce gastroenteritis, fever, myalgia, petechial hemorrhage, and eosinophilia.<sup>1</sup> More severe infections include parasitic invasion of cardiac muscle leading to myocarditis.<sup>4</sup> Dyspnea results from diaphragm and accessory muscle encystment.<sup>1</sup> Finally, neurotrichinellosis is the consequence of infection of the central nervous system.<sup>1,5</sup>

For the *Enterobius vermicularis* life cycle, humans are primary hosts for this organism. Also known as the pinworm, *E. vermicularis* spends most of its existence in the lumen of the gastrointestinal tract.<sup>1,6</sup> However, eggs are laid on perianal skin; and transmission occurs

from scratching and the eventual ingestion of ova via contaminated hands, food, or water. This organism is arguably the most common helminthic infection in humans, with prevalence rates of up to 100% and no predilection for any socioeconomic group.<sup>7</sup> While pruritis ani or perianal pruritis remains the most common symptom, insomnia, irritability, weight loss, and enuresis also are associated with pinworm infestation, especially in children.<sup>1, 6, 8</sup> Vulvovaginitis secondary to vaginal infection has occurred in some individuals.<sup>9,10</sup>

Like humans, cockroaches also serve as hosts in the life cycles of some helminths. These helminths, such as *Hammerschmidtella*, *Blatticola*, and *Thelastoma*, are not primarily human parasites.<sup>11-14</sup> However, helminth transmission to humans occurs, as in the case of *Gongylonema*, which is likely secondary to the consumption of infected insects.<sup>15-18</sup>

While *Trichinella* is known to infect humans, this helminth has never been reported in the cockroach. For *Enterobius*, only ova without any mature organisms have been documented in roaches.<sup>19,21</sup> The present work is the first report characterizing *Trichinella* and *Enterobius*-infestation in wild cockroaches. Furthermore, this finding supports the idea that cockroaches act as hosts for these human parasites. Due to the ubiquitous nature of the cockroach, potential public health concerns are evident.

## Methods

### Roach Acquisition

Roach traps (Hoy Hoy Trap-A-Roach, Earth Chemical Company, Tokyo, Japan) were placed in various grade schools and hospitals across Honolulu, HI. The roaches were harvested from the traps and then fixed in 10% formaldehyde for greater than 24 hours.

### Microscopy

The fixed cockroaches were bisected and embedded in paraffin for slide preparation. The slides were stained with hematoxylin and eosin. All slides were analyzed by J.J.N.

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## Results

### *Trichinella* Infestation in the Cockroach

Figure 1 demonstrates the encystment of *Trichinella* in the skeletal muscle of a wild cockroach obtained from a grade school. This is an example of one of two roaches found in this environment. While this histologic finding does not allow us to conclusively identify the species of this helminth, the histology is characteristic of the genus *Trichinella*.

### *Enterobius vermicularis* Infestation in the Cockroach

Figure 2 demonstrates *E. vermicularis* in the lumen of the gastrointestinal tract of a wild cockroach. This is an example of one of six roaches found in a local grade school and hospitals. The lateral spines shown in the cross section of this organism support the identification of *E. vermicularis*.

In this study, examination of the fecal pellets of the *Enterobius*-infected roaches did not yield any ova. Nevertheless, Sondak isolated eggs from the rectums of Oriental (*Blatta orientalis*) and German (*Blattella germanica*) cockroaches.<sup>19-21</sup> The present work documents mature *Enterobius* infestation in wild roaches. Table 1 is a summary of the *Trichinella* and *Enterobius* infestations by location.

## Discussion

This is the first description of *Trichinella* and *Enterobius* infestations in wild cockroaches in Hawaii. The significance of this preliminary study identifies the roach as an unappreciated host in the life cycle of these nematodes. As a host, the cockroach can act as a reservoir for these human parasites, potentially enabling the persistence and transmissibility of *Trichinella* and *Enterobius* in the environment.

It is known that cockroaches can harbor a variety of infective human pathogens.<sup>13</sup> Roaches are natural carriers of pathogenic bacteria, such as *Salmonella*, *Pseudomonas*, and *Klebsiella*.<sup>22-33</sup> Cockroaches also are able to acquire and excrete Coxsackievirus and Hepatitis B virus in the laboratory.<sup>19, 34, 35</sup> Finally, at least two pathogenic fungi, *Aspergillus fumigatus* and *Aspergillus niger*, were found on wild roaches.<sup>19, 34</sup> The present work describes human-parasitic helminths previously unknown to infest cockroaches.

The aim of this report is to identify the cockroach as a natural host of the human pathogens, *Trichinella* and *Enterobius*. It is interesting to note that the helminth infections in this study were seen only in the American cockroach (*Periplaneta americanus*). Infestation was not observed in the Brown-banded cockroach (*Supella longipalpa*) or the German cockroach (*Blattella germanica*) samples. Of these roach species, *Trichinella* and *Enterobius* may have a selective tropism for *P. americanus*. Perhaps, the larger size of the gastrointestinal tract or muscle mass of *P. americanus* enables

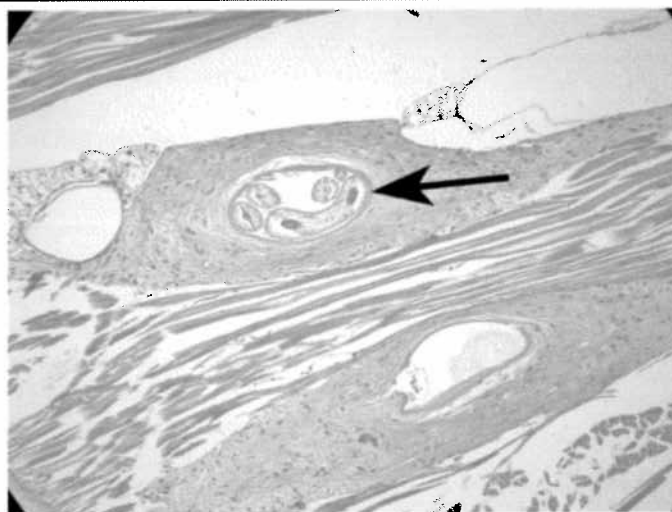


Figure 1.— *Trichinella* infection in the cockroach.

Light microscopy demonstrates the cross-section of *Trichinella* spp. (arrow) encysted in roach skeletal muscle. This figure is a representation of one of two roaches obtained from a grade school (40x).

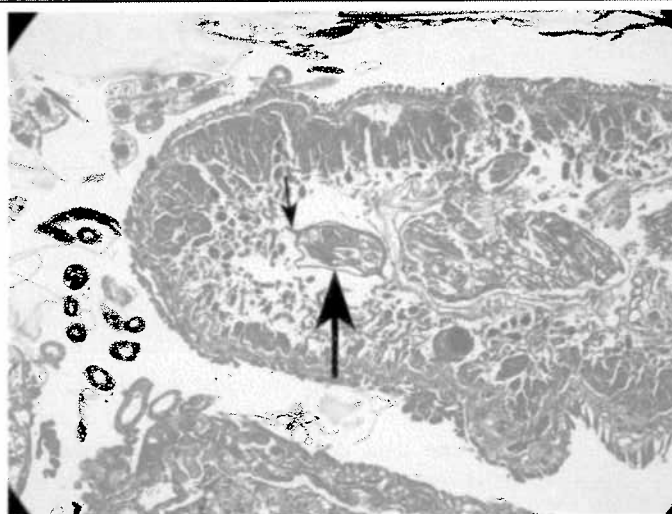


Figure 2.— *Enterobius vermicularis* infection in the cockroach.

Light microscopy demonstrates the cross-section of *E. vermicularis* (large arrow) in the lumen of the roach gastrointestinal tract. The lateral spines (small arrow) of this organism support the identification of *E. vermicularis*. This figure is a representation of one of six roaches obtained from a grade school and hospitals (100x).

Table 1.— *Trichinella* and *Enterobius* infestations in wild cockroaches.

The number of infested roaches obtained from each location is shown and organized by infecting nematode. Total sample sizes of cockroaches are indicated (n). The values represent individual roaches. Percentages of the specified groups are indicated in parentheses. The roaches were captured over a 3-4 month period.

Location	<i>Trichinella</i>	<i>Enterobius</i>
Grade school (n=165)	2 (1%)	4 (2%)
Hospitals (n=9)	0 (0%)	2 (22%)
TOTAL (n=174)	2 (1%)	6 (3%)

the helminths, especially *Trichinella*, to infect this cockroach species versus the smaller *S. longipalpa* and *B. germanica*. However, sampling bias cannot be ruled out, given that the majority of the captured roaches were *P. americanus* as opposed to the other roach species. This idea has not been fully resolved.

*Trichinella* can infect a variety of mammals, including pigs, rats, mice, and even cats.<sup>2,3,36-39</sup> Additionally, a 1936 study demonstrated infected mongooses from the islands of Hawaii and Maui,<sup>2</sup> probably as a result of preying on infected rodents. Infection is passed on to another animal by consumption of encysted larvae found in muscle.<sup>1,2</sup> Our results show that *Trichinella* parasitism occurs in naturally occurring cockroaches (Figure 1). The authors hypothesize that roaches become infected by ingesting *Trichinella* larvae from the flesh of an infected animal. Indeed, rodents and mongooses are likely present in the surroundings of the grade school from which the infected roaches were obtained.

*E. vermicularis* was identified in the gastrointestinal tract of roaches from grade school and hospital settings (Figure 2). The majority of infections occur in children,<sup>8, 40-46</sup> and grade schools may serve as likely environments for *Enterobius* ova. It is possible that the roaches ingest eggs from the environment; and the ova mature in the roach gastrointestinal tract (Figure 2). From here, it is unclear if the cockroach acts as an intermediate host in the life cycle of *E. vermicularis* or if the roach is an end-stage host, where the nematode does not pass to another host. It has not been determined if gravid females expel eggs from the roach gastrointestinal tract and into the environment. A preliminary survey of our infected roaches revealed that no ova were observed in fecal pellets. However, this does not rule out transmissibility because *E. vermicularis* ova are seldom identified in human feces.<sup>1</sup> More work is required to elucidate the cockroach's specific contribution to the life cycle of *E. vermicularis*. Nevertheless, it is interesting to note that in 1935 Sondak did document *E. vermicularis* ova in Oriental and German cockroaches in Leningrad.<sup>20,21</sup> The present work demonstrates mature pinworm infection in wild roaches and adds the American cockroach as a host.

This preliminary study highlights the role of the cockroach as an unappreciated host for the human parasites, *Trichinella* and *Enterobius*, and gives rise to potential public health concerns. As a host, the cockroach serves as an additional reservoir for these helminths, enabling their persistence in our environment. Animals that consume infected cockroaches may become unwittingly infected and promote the life cycle of the helminths. Given that pigs are known reservoirs for *Trichinella*, this has implications for slaughterhouses where cockroach infestation may be an issue (i.e. ingestion of infected roaches in animal feed). Any attempts to eradicate *Enterobius* and *Trichinella* should

take cockroach control into consideration, as roaches harbor these helminths. Finally, such information may have diagnostic value when trying to identify the origin of infection in helminth-infested individuals.

The transmission of helminths from cockroaches to humans has been discussed before. The helminth *Gongylonema* requires an intermediate insect host, such as a cockroach or dung beetle, to ingest its eggs.<sup>47, 48</sup> Human infection has been suggested to be secondary to accidental ingestion of infected insects<sup>49</sup>, and *Gongylonema* infestation has been documented in several persons.<sup>15-18, 50</sup>

The *Trichinella* and *Enterobius*-infested roaches in this study were obtained at sites in Honolulu located at least five miles apart from each other. This indicates that the results are not geographically isolated to one neighborhood and may be more extensive given the ubiquitous nature of the cockroach. Also, the results show that there is no limitation in the institutional setting, varying from grade schools to hospitals.

While cockroaches are known carriers of human pathogens, there is debate regarding whether roaches are actual vectors for human disease. Some investigators argue that no conclusive study exists to link cockroaches and human illness.<sup>51</sup> Unfortunately, our results at this time do not provide decisive evidence to support or dispute such a connection. Instead, the present work does call to attention that cockroaches are hosts for *Trichinella* and *Enterobius* and identifies a previously undescribed reservoir for these human pathogens. Hopefully, such information may be used to guide future research, clinical diagnoses, and public health decisions.

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